Coastal Hazards

Learning Objectives

- Understand coastal processes, such as waves, beach forms and processes, and rising sea level
- Understand coastal hazards, such as rip currents and erosion
- Know what geographic regions are at risk for coastal hazards
- Understand the effects of coastal processes, such as effects off coastal processes, such as rip currents, coastal erosion, and rising sea level
- Recognize the linkages between coastal processes and other natural hazards
- Know the benefits derived from coastal processes
- Understand how human use of the coastal zone affects coastal processes
- Know what we can do to minimize coastal hazards
- Understand the adjustments that can be made to avoid damage from coastal erosion and rising sea level or personal injury from strong coastal currents

Coastal Topography

- Overall, coastal topography is greatly influenced by plate tectonics
    - Difference in where you live
        - The East Coast of the US and Canada is considered to be tectonically passive, although there are still coastal hazards
        - The West Coast of the US and Canada, including Alaska, is tectonically active, increasing the coastal hazards
- Unfortunately, these coasts are the places where most of the populations live
- Once again people tend to build their cities in the way of hazards

Impact of Waves and Currents on the Landscape

- Affect only a tiny fraction of the total Earth's surface
- Create a landscape almost totally different from any other
    - Waves are agents of erosion
    - Currents are agents of transportation and deposition
    - Notable land features
    - Rocky cliffs, headlands, beaches, and sandbars
- Beaches the transition between shoreline and water

Coastal Hazards

- The most **serious coastal hazards** are the following for coastal areas
    - Strong coastal currents, rip currents generated surf zones and tidal currents in narrow bays and channels

- Coastal erosion producing considerable property damage
- Storm surge from cyclones which can claim many lives and enormous property damage
- Occasionally tsunamis can be particularly hazardous to coastal areas on the Pacific Coast

Coastal Processes

- Coastlines extend for hundreds of thousands of kilometers.
- Every kind of structure, relief, and topography can be found along coastlines
- Distinctiveness of the coastal milieu
- Interface three major components
  - **Lithosphere, hydrosphere, and atmosphere**
  - **Dynamic and highly energetic, restless motions of the waters**
- Along with water, **wind** has greater influence on the topography because surface of a large body of water can be deformed abruptly and rapidly by wind action.
- The deformation of water surface creates waves and ocean currents
  - Shapes the coastlines
  - Produces topographic features found around the world
- Exceptions to these processes
  - **Along lake shores**, ranges in tides too small and insignificant to landform development
  - Causes of **sea-level fluctuations are quite different from the causes of lake level fluctuations**
  - **Coral reefs are built only in tropical and sub-tropical oceans, not in lakes**
- **Daily Tidal** - fluctuations move enormous amounts of water
- **Diastrophic** (like Earthquakes) – contribute to water motion
- **Long term variations in sea or lake level** caused by tectonic forces
- **Eustatic sea-level - decrease or increase in sea level**, in the world oceans

Coastal Landforms

- **Emergent Shoreline**s
  - **Ancient shorelines** – almost all coastlines show evidence of submergence during the last 15,000 years
    - Ria shorelines – Drowning of previous river valleys
      - Produces long estuaries of sea water projecting inland
    - Fjoid Coasts – Coastlines occur where high-relief terrain has undergone extensive glaciations.
      - Deep sheer-walled coastal indentations
- **Shorelines associated with tectonic lift**
  - Clearest topographic result of coastal emergence of shoreline features
    - Wave-cut Cliffs and Platforms

        - Comprises wave cut beaches and wave built terraces
    - Marine Terraces
        - Wave-cut platform is uplifted along tectonic rising coast
- **Beaches** - Occupies the transition zone between land and water
    - **Backshore** – upper part of beach
    - **Berms** – flattish wave-deposited sediment platform
    - **Foreshore** - zone regularly covered and uncovered by rise and fall of tides
    - **Offshore** - zone that is permanently under water
- **Spits** - Growing linear deposit of material attached to the land extending into open water in a down-current direction
    - **Baymouth Bar** – (bay barrier) a spit that progresses across a bay or form a lagoon
    - **Tombolo** – spit shape is caused by conflicting water movements- forms a hook
- **Barrier Island** - A long narrow sandbar built up in a shallow offshore waters
    - Results from the heaping up of debris where long waves begin to break in shallow waters of continental shelves
- **Lagoon** - A body of water between the mainland and a spit or baymouth bar of salty or brackish water

Waves

- **Wave Size and Shape** is a combination of:
    - **The velocity of the wind**: the stronger the wind speed, the larger the waves
    - **The duration of the wind**: the longer lasting the wind, during storms, the more energy is forced on the water, creating larger waves
    - **The distance that the wind blows across the water surface: this is the *fetch*.** A longer fetch allows larger waves to form. This is more effective in the ocean than in a lake

Parts and Measurements of Waves

- As Wave moves forward a **Crest** is formed
- Followed by the **Wave Trough**
- Distance between crest to crest is the **Wavelength**
- Vertical distance from top of crest to bottom of the trough is the **Wave height**
- Height of a wave depends on
    - **Wind speed**
    - **Wind duration**
    - **Water depth**
    - **Fetch (area of open water)**
- **Wave amplitude-** ½ the height of the vertical distance from still water either to the crest or the trough
- **Waves often travel great distances across deep water with little change in the shape or speed**
- **BUT when a wave reaches shallow water changes happen:**
- **When water depth becomes equal to half the wave length, wave motion begins to be**

effected by the frictional drag or the sea bottom

Waves

- **Wave Motion**
  - The **form of the wave as it moves through the water**
  - **Water itself shifts only slightly**
  - In **shallow water waves crests and breaks**
  - **Wind generates most waves**
    - Set in **motion largely by the friction of air blowing across the water**
    - This is a **transfer of energy from the wind to the water**
- **Two Major Kinds of Waves**
  - **Water waves (called "forced waves")**
    - Generated by wind stress on the water surface
    - Develop into considerable size and turbulence
    - Limited existence and don't travel far
  - **Swells**
    - Waves that escape the influence of the generating wind
    - Travel enormous distances
  - Small number of waves not caused by wind
    - Tidal Surge
    - Volcanic Activity

- **Waves of Oscillation and Transition**

  - **At a given point on top of water surface there is a point of oscillation**
    - **Oscillation** – move back and forth over one place
    - These are **Waves of Oscillation**
  - **Resulting from horizontal movement of the surface water**
    - These are **Waves of Transition**
  - **Waves of Transition**
    - **Results in horizontal movement of the surface water**
    - **Friction retards the movement**
      - **Waves bunch together**
      - **Decrease in wave length**
      - **Height increases**
      - **Drag increases- until instability**
      - **Wave breaks – resulting in**
        - Whitewater surf
        - Plunging forward as a breaker
        - Surging up the beach without cresting
    - After breaking the water becomes turbulent **– Swash washes up the shore**
    - Carries sand and rock particles onto the beach or rocky headlands or sea cliffs
      - **The reverse of Swash is called Back Wash**

Changes in Sea Level & Lake Level

- Changes can result from either uplift or sinking of land mass (tectonic caused)
- OR increase/decrease in amount of water in the oceans
    - Ecstatic Sea Level Change
- Global Warming and Sea level changes
    - What will it do to coast lines of the world if the ice caps of Antarctica and Greenland melt?
    - Global sea level would rise 80 meters (260 feet)

Wave Erosion

- Notable coastal erosion caused by wave action
    - Incessant pounding of the waves wears away the shoreline
        - Speed coupled with mass of water and rock particles
    - Another dimension of wave erosion- air is forced into cracks
        - Pneumatic action is often very effective
    - Chemical action also is effective erosion
        - Dissolves some rocks
- **Cliffs**
    - Most effective erosion takes place just above sea level
    - Clift face retreats slope above
    - Undercut slope collapse
    - Resulting debris is broken, smoothed and made into smaller pieces by further wave action

Effects of Coastal Processes

- **Wave Refraction**
    - Where waves change direction
        - Happens when waves do not approach a shore exactly parallel
        - Part of the wave arrives sooner- slows faster and "bends" the wave
        - Tends to smooth the coastal outline by wearing back the headlands and increasing sediment accumulation in the bays

Beach Form and Processes

- Although erosion happens on shoreline - **Deposition** also occurs
    - **Maritime deposition** is more ephemeral than non-coastal deposits
        - Due to more sand and less stabilization due to vegetation cover
    - **Sediment budget** must be in balance if the deposit is to stay stable
        - Removal of sand must be offset by additional sand
- **Ice Push**
    - Shores of bodies of water that freeze over winter are effected by Ice Push
    - Results in contraction and expansion
    - Frost wedging from the expanding ice pushed into the shore causes more erosion
- **Organic Secretions**
    - Coral polyps live in tropical ocean areas
    - Coral reefs are developed from the outer skeletons of these polyps
- **Stream Outflows**
    - Outflow of streams and rivers into oceans and lakes feed the sediment in water
    - Supply the sediment that is moved by the waves

Geographic Regions at Risk for Coastal Hazards

- **Coastal hazards are present on both sea coasts and lake shores**
    - The **Great Lakes of North America are more susceptible**
- **Hurricanes and tsunamis hazards** are generally absent in lakes
- **Coastal erosion is a more universal hazard**
- There are **various causes for coastal erosion**
    - **Rip Currents**
    - **Tides**
- **At the greatest risk for rising sea level are:**
    - **Coasts and islands that are close to sea level today**

Effects of Coastal Processes

- **Rip Currents**
- Where waves change direction
    - Happens when waves do not approach a shore exactly parallel
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- **Beach Drifting**
    - Involves the short distance shifting of sand directly on shore by breaking waves and directly offshore by retreating water
    - Movement is in a zig-zaging movement of particles
    - Move because of the oblique direction of wave hitting the shore

Tides

- Significant agents of erosions in only:
    - Narrow bays

    - Shallow seas
    - Passages between islands where strong currents scour the sea bottom and cliffs and shorelines

Tsunamis

- Sudden disruption of the ocean floor
- Entire water column is disrupted by uplift of ocean floor
- Nearing the shore line wave length is decreased and the wave height is increased
- Rapid advancing surge of water up to 40 meters high

Effects of Coastal Processes

- **Cliff Erosion –** Problems with erosion from a combination wave actions and land erosion by running water and landslides.
    - This is also compounded by people who make poor development choices on cliffs
    - Cliffs erode like the knickpoint on a stream or river
    - As the wave action pound the cliff, the cliff will begin to "retreat"
    - Not always easy to detect at low water, but easy to detect during high water

Linkages with Other Natural Hazards

- **Coastal Processes are often linked to other natural hazards, such as earthquakes, volcanic eruptions, tsunamis, cyclones, flooding, landslides, subsidence, and climate change**.
- Besides natural hazards, there are the man-made hazards which seem to happen all to often.
    - Looking at the latest oil spill in the Gulf of Mexico
    - It destroyed beaches, killed wildlife, and destroyed the wetlands found along the Louisiana Delta

Natural Service Functions of Coastal Processes

- The beauty of coastal areas of the world are one of the natural services of the coastal processes
- There is also a renewal of the ecosystems through the coastal processes
- There are the development of coral reefs which are areas wonderful areas for fish and mammals to live in
- These beaches along coasts also give us great recreational areas for swimming, surfing, sailing and fishing.

Natural Services of Coastal Processes

- Coral Coast
    - Coral reefs or other type of coral line formation found around islands in the tropics
    - Critical element in development of coral reefs is a group of entozoan animals called stony corals.
    - Great Barrier Reef an example

- Volcanic coral reefs
    - Coral animals accumulate around the volcano
    - As coral increases the volcano sinks
    - When volcano sinks completely the coral reef becomes an atoll

Human Interaction with Coastal Processes

- **Human interference with natural shore processes has caused considerable coastal erosion**
- Efforts to sop coastal erosion involve engineering structures to impede the transport
- These artificial barriers interrupt the movement of sand, causing beaches to grow in some areas and erode in others
- This saves valuable beachfront property

Human Alterations on Coastal Areas

- **Dams** - built so less sediment reaches the mouth of rivers
    - Changes beaches
- **Artificial structures** - built to stabilize beaches
    - Reduces sediment transport down shore
    - Dumping tons of sand up-current from beach, doesn't work
- **Groin** – short wall or dam built from a beach to impede longshore currents and force sand deposition
    - Problem erosion breaks down the groin
    - A field of groins are built
- **Jetties** – Built in pairs on either side of a river or harbor entrance
    - Confines the flow of water into a narrow zone
    - Keeping the sand in motion and inhibiting its deposition in the navigation channel

Coastal Landforms
Perception of and Adjustment to Coastal Hazards

- People generally perceive land as being stable and permanent
- This is appropriate for many areas, but coastlines are dynamic, shorelines erode, accumulate, and move in time frames of months and years
- Even though people are told of the dangers of the erosion of coastal areas, they keep

building closer, they treat them with no care, and they don't realize the damage they do in a very short time.

Adjustment to Coastal Hazards

- There are ways we can adjust to shorelines with strong currents, coastal erosion, and rising sea level.
- There are three adjustments that will help with coastal erosion categories
    - Beach nourishment that tends to imitate natural processes –the "soft solution"
    - Shoreline stabilization through structures, such as groins and seawalls– "hard solution"
    - Land-use change that attempts t avoid the problem by not building in hazardous areas or by relocation of threatened buildings – the "managed retreat solution."